Studies Supporting Radiation Hormesis Notes

This presentation addresses the results of radiation exposure studies that support radiation hormesis.

Slide 2 – radiation exposure studies supporting hormesis

- radium dial painters
- atomic bomb survivors
- nuclear shipyard workers
- other nuclear workers
- Canadian fluoroscopy study
- Non-Hodgkin's lymphoma trial
- Taiwan apartment dwellers

Slide 3 – radium dial painters

- beginning about 1915, many women employed in well-paying jobs to paint hands and faces of clocks and watches with radium paint
- ingested Ra-226 from twirling tip of brush between lips to make fine point
- at that time little was known about radiation or its effects
- suffered chronic exposure to internal high LET radiation (alpha particles)

Slide 4 – dial painters (cont.)

- selective reporting of information led to belief that most radium dial painters died from radiation-induced cancer
- in 5 years, 18 dial painters developed necrosis of jawbones and pernicious anemia from high total absorbed doses
- other high-dose recipients developed osteosarcomas
- 30-year follow-up of 1155 low-dose recipients showed lower cancer incidence than general population and longer lifespans

Slide 5 – dial painters (cont.)

- no observed incidence of osteosarcomas for total absorbed dose below 10 Gy
- except for breast cancer, other cancer mortality rates showed no change from general population
- observed breast cancer mortality rates showed no relation to total absorbed dose
- leukemia mortality lower than expected for U.S. dial painters
- no leukemia deaths and increased average lifespan observed for British dial painters

Slide 6 – dial painters (cont.)

- Doctors Robley Evans and Robert Rowland reported no occurrences of bone cancer or nasal carcinomas for Ra-226 intakes <250 µCi
- produced estimated total absorbed dose of 10 Gy to bone
- 64 bone sarcoma occurrences in 264 cases with >10 Gy exposure
- no sarcomas or nasal carcinomas in 2119 cases with <10 Gy exposure
- no other malignancies or syndromes statistically associated with radium deposited in human body

Slide 7 – dial painter intake graphic

- graphic shows clear Ra-226 activity threshold of 100 µCi for increased cancer risk
- established absorbed dose threshold for high LET radiation-induced cancer of 10 Gy
- note that this is not cumulative dose over years, but threshold dose from accumulation of radium in bones

Slide 8 – graphic showing 10 Gy threshold dose for radium dial painters

Slide 9 – atomic bomb survivors

- about 200,000 Japanese killed from atomic bombs dropped on Hiroshima and Nagasaki
- vast majority killed from thermal blast (fireball) and subsequent shockwave that destroyed occupied buildings
- <10% of deaths from ARS
- survivors subjected to high, acute radiation doses extensively studied by Radiation Effects Research Foundation (RERF) - cancer mortality database for about 86,000 survivors

Slide 10 – atomic bomb survivors (cont.)

- conclusions about effects of acute radiation exposure generally based on data from Japanese atomic bomb survivors
- survivor cancer mortality compared with people 3-10 km from ground zero (in-the-city cohort) and unexposed people in villages northwest of Hiroshima (out-of-city cohort)
- in-the-city cohort received some radiation from bombs and from residual radiation inside 3 km radius

Slide 11 – atomic bomb survivors (cont.)

- cancer mortality rate of those receiving 1-1.9 cSv exposure less than both control populations
- those receiving <20 cSv had essentially same mortality rate as out-of-city control population
- those receiving >20 cSv showed increasing cancer death rate with increasing dose

Slide 12 – atomic bomb survivors cancer mortality graphic

- data clearly indicates hormesis effect for acute doses below 3 cSv and threshold for increased cancer risk at about 20 cSv

Slide 13 – atomic bomb survivors (cont.)

- subsequent studies confirm reduced cancer and leukemia mortality, and increased average lifespan
- no increase in total cancer deaths for those receiving <20 cSv exposures
- leukemia mortality even lower for exposures <10 cSv
- UNSCEAR-1958 leukemia incidence data shows threshold at 50 cSv

Slide 14 – atomic bomb survivors (cont.)

- life expectancy of survivors higher than control groups
- no adverse genetic effects found in survivors' progeny
- low doses of ionizing radiation reduced genetic abnormalities

Slide 15 – atomic bomb survivors genetic abnormalities graphic

- ZEP – zero equivalent point
- genetic abnormalities in Japanese babies decreased in mothers exposed to < 20 cGy from atomic bombs
- data clearly show threshold for increased risk of genetic abnormalities at 20 cGy

Slide 17 – nuclear shipyard worker study

- one of largest and most thorough studies of effects of chronic low-level radiation exposure completed in 1987
- 10-year study of naval shipyard nuclear workers and non-nuclear workers
- nuclear workers exposed to Co-60 radiation in reactor coolant system piping and valves

Slide 18 – nuclear shipyard worker study (cont.)

- 2 nuclear worker groups
  - high cumulative dose effective (> 5 mSv)
  - low cumulative dose effective (< 5 mSv)
- cumulative dose effective – summation of individual irradiated tissue and organ doses
- high-dose group mortality rate 76% of non-nuclear worker group rate
- low-dose group mortality rate 81% of non-nuclear worker group rate

Slide 19 – other nuclear workers

- evidence from studies involving > 7 million nuclear worker person-years show that low doses of external ionizing radiation decrease total cancer mortality rates

- studies of nuclear workers and non-nuclear workers in nuclear fuel cycle and nuclear weapons complex activities summarized in 1997
- cancer mortality rate for nuclear workers was 60% of non-nuclear worker rate

Slide 20 – cancer mortality rate table for nuclear worker studies
- two numbers in Population and Deaths columns signify control and exposed groups, respectively
- data clearly show hormesis effect for low-dose radiation

Slide 22 – Canadian fluoroscopy study
- 1989 study of breast cancer incidence in Canadian women treated for tuberculosis with high doses of x-rays
- found statistically significant reduction in breast cancer for acute radiation exposures <30 cGy

Slide 23 – breast cancer mortality vs dose graphic
- clearly shows threshold dose about 30 cGy for increased cancer risk

Slide 24 – non-Hodgkin's lymphoma trial
- 9-year non-Hodgkin's lymphoma clinical trial
- 23 low-dose radiation patients and 94 control (unirradiated) patients
- survival of low-dose patients 84% at 10 years compared with 50% for control patients

Slide 25 – non-Hodgkin's lymphoma trial survival rate graphic
- graphic shows low dose radiation treatment improves survival rate of non-Hodgkin's lymphoma patients

Slide 27 – Taiwan apartment dwellers study
- Co-60 contaminated steel used in construction of 200 apartment buildings in 1983
- 10,000 residents received average collective dose of 400 mSv (400 mGy) between 1983 and 2002
- first year doses ranged from 18 to 525 mSv, with average dose of about 78 mSv

Slide 28 – Taiwan apartment dwellers study (cont.)
- 20-year cancer mortality rate for apartment dwellers assessed at 3.5 per 100,000 person-years, compared with 116 cancer deaths per 100,000 person-years for general Taiwan population
- births with congenital heart malformations assessed at 1.5 cases per 1,000 children, compared to 23 cases per 1,000 children in general population

Slide 29 – Taiwan apartment dwellers cancer mortality rate graphic
- data clearly indicate hormesis at work for apartment dwellers

- during same time period, something caused steady increase in cancer mortality for general public

Slides 31-34 – summary of studies providing evidence to support radiation hormesis